

# **Part III**

## **Astrometry**



## Chapter 10

# Wide-Angle Astrometry

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The goal of wide-angle astrometry is to determine accurate relative-positions of stars that are widely separated on the sky. The problem via interferometry is to recover the two coordinates for each star from the observed delays. In principle, sufficient delay measurements would allow the baseline vectors of the interferometer to be determined along with the delay constants and the positions of the stars. However, the actual situation is greatly complicated by the presence of the atmosphere and the fact that neither the delay “constants” nor the baseline vectors are stable over time. The design of, and the analysis of the data from, any ground-based optical interferometer must overcome all three of these effects. The design, operation, and the analysis of data from the Navy Prototype Optical Interferometer (NPOI) are here presented as examples of how to overcome the effects of the atmosphere and the instrumental instabilities in order to achieve accurate wide-angle astrometry. The status of the implementation of these techniques at the NPOI is presented.

### 10.1 Introduction

The Navy Prototype Optical Interferometer (Armstrong *et al.*, 1998a), located on Anderson Mesa, AZ (Figure 10.1), is a joint project of the U.S. Naval Observatory and the Naval Research Laboratory in cooperation with the Lowell Observatory. The NPOI includes arrays for imaging and for astrometry. The imaging array consists of six movable 50-cm siderostats feeding 12-cm apertures, with baseline lengths from 2.0 m to 437 m. The astrometric array consists of four fixed 50-cm siderostats feeding 12-cm apertures (soon to be increased to 35 cm), with baseline lengths from 19 m to 38 m. The arrays share vacuum



Figure 10.1: An aerial view of the NPOI showing the array as viewed from the north-east. The road surrounding the array can be seen along with parts of the north (right) west (center) and east (left) arms of the imaging array (station piers and vacuum feed lines visible). The astrometric siderostat shelters are the white structures at the array center. The beam-combining laboratory is the long structure to the right of the array center, with the ‘long’ delay line vacuum tanks (under construction) extending towards the north. The interferometer control building appears at the far right-center.

feed and delay-line systems. The NPOI features rapid tip-tilt star tracking, active group-delay fringe tracking over a wide band (450–850 nm in 32 channels), and a high degree of automation. The astrometric array includes an extensive baseline metrology system to measure the motions of the siderostats with respect to the local bedrock to 100 nm accuracy. Additional details of the NPOI design can be found in Armstrong *et al.* (1998b), Clark *et al.* (1998), Mozurkewich (1994), and White *et al.* (1998).

The initial goal of wide-angle astrometric observations with the NPOI will be to produce a catalog of positions for  $\sim 1000$  of the brighter Hipparcos stars with an internal accuracy of 1–3 mas. Astrometric observations of radio stars will be used to orient the NPOI catalog with respect to the fundamental reference frame defined by extragalactic radio sources. With an anticipated operational lifetime of more than a decade, the NPOI will significantly improve the measured proper motions of these (and additional) stars. (Hipparcos positional accuracies will have already degraded to  $\sim 10$  mas by 2001 due to proper motion uncertainties.) Position measurements repeated at regular intervals will also allow unambiguous separation of binary motion from proper motion, an accomplishment that might be difficult to achieve from space-based observations that are likely to be repeated only at intervals of decades.